Introduction to VoIP – Voice Over Internet Protocol

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What is VoIP?

- Voice over Internet Protocol is a general term for a family of transmission technologies for delivery of voice communications over IP networks such as the Internet or other packet-switched networks
- Other terms frequently encountered and synonymous with VoIP are IP telephony, Internet telephony, voice over broadband (VoBB), broadband telephony, and broadband phone
- Voice over IP systems carry telephony signals as digital audio, typically reduced in data rate using speech data compression technologies, encapsulated in a data-packet stream over IP

Advantages of VoIP

- Differences from PSTN Network
- Ability to transmit more than one call over the same broadband connection
- Conference calling, IVR, call forwarding, automatic redial and caller ID are free
- Bandwidth efficiency and Low cost
- Location Independence - Only an internet connection is needed to get a connection to a VoIP provider
- Integration with other services available over the Internet, including video conversation, message or data file exchange in parallel with the conversation, audio conferencing, managing address books, and passing information about whether others, e.g., friends or colleagues, are available to interested parties
- Supports voice, data and video
- Secure calls using standardized protocols (such as Secure Real-time Transport Protocol)

Challenges

- **Bandwidth Availability** - Needs a reliable net connection
- **Quality Of Service** - Because the underlying IP network is inherently unreliable, in contrast to the circuit-switched public telephone network, and does not inherently provide a mechanism to ensure that data packets are delivered in sequential order, or provide Quality of Service (QoS) guarantees, VoIP implementations face problems such as
  - Packet Loss
  - Latency
  - Jitter
  - Out Of Order delivery
- Susceptibility to power failure
- **Security** - Voice over Internet Protocol telephone systems (VoIP) are susceptible to attacks as are any internet-connected devices
- **Emergency calls** - The nature of IP makes it difficult to locate network users geographically

VoIP Protocols

- H.323
- Session Initiation Protocol (SIP)
- Media Gateway Control Protocol (MEGACO / MGCP)
- SIGTRAN suite of protocols - To carry signaling (ISDN / SS7) over IP
- Session Description Protocol (SDP) - To describe media channels or streams
- Real Time Transmission Protocol - For media (voice, video or data) transmission

H.323

- The first VoIP protocol defined by ITU-T
- It is a standard for multimedia communication over IP network

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Session Initiation Protocol (SIP)

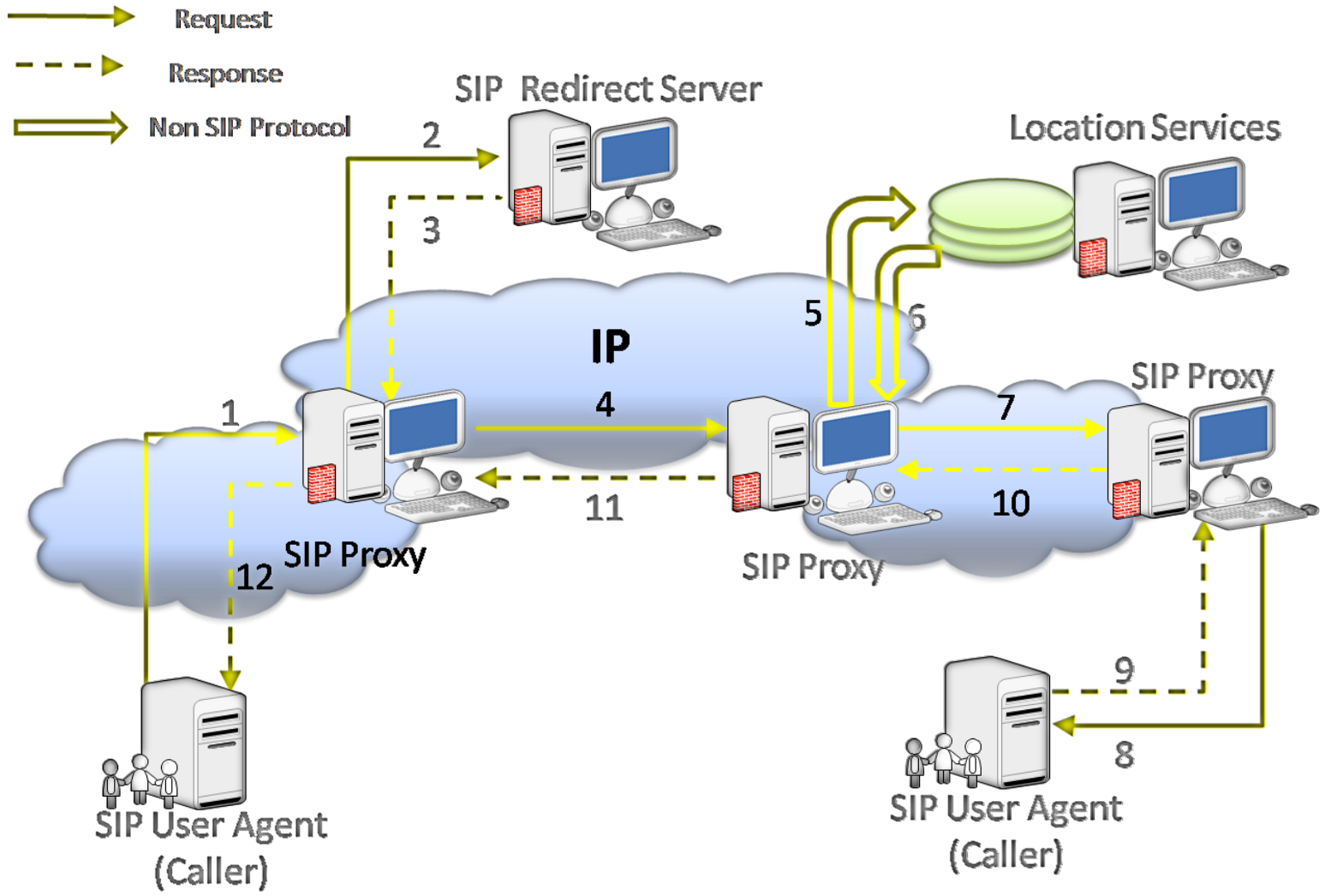
Introduction

- SIP is an application layer control (signaling) protocol for creating, modifying, and terminating sessions with one or more participants.
- Direct competition with H.323
- Looks to be protocol of the future
- Microsoft migrated from net-meeting (H.323) to MSN messenger / windows XP(SIP)
- SIP message format is based on the Hyper Text Transport Protocol (HTTP) message format, which uses a human-readable, text-based encoding

Introduction

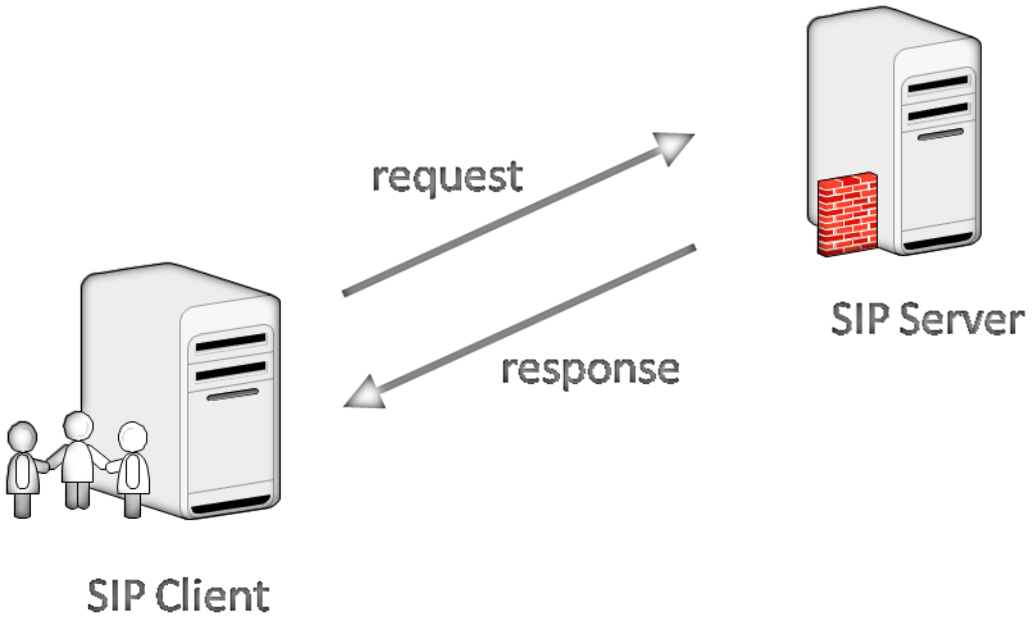
- SIP is transport-layer independent protocol that can be used with any datagram or stream protocol like UDP, TCP, SCTP, ATM etc
- It uses the session description protocol (SDP) for media negotiations (similar to MEGACO / MGCP)
- Simple, Extendable and most promising
- SIP is also the most preferred protocol choice for communication between MGCs (Call Agents).
- Accepted as the core signaling protocol for 3rd generation (3G) wireless

Architecture



- Consists of User Agent, Network server (proxy, redirect, registrar and location server)

User Agent



- End system acting on behalf the user
- User Agent Client (originator) and User Agent Server (terminator)
- Maintains call state

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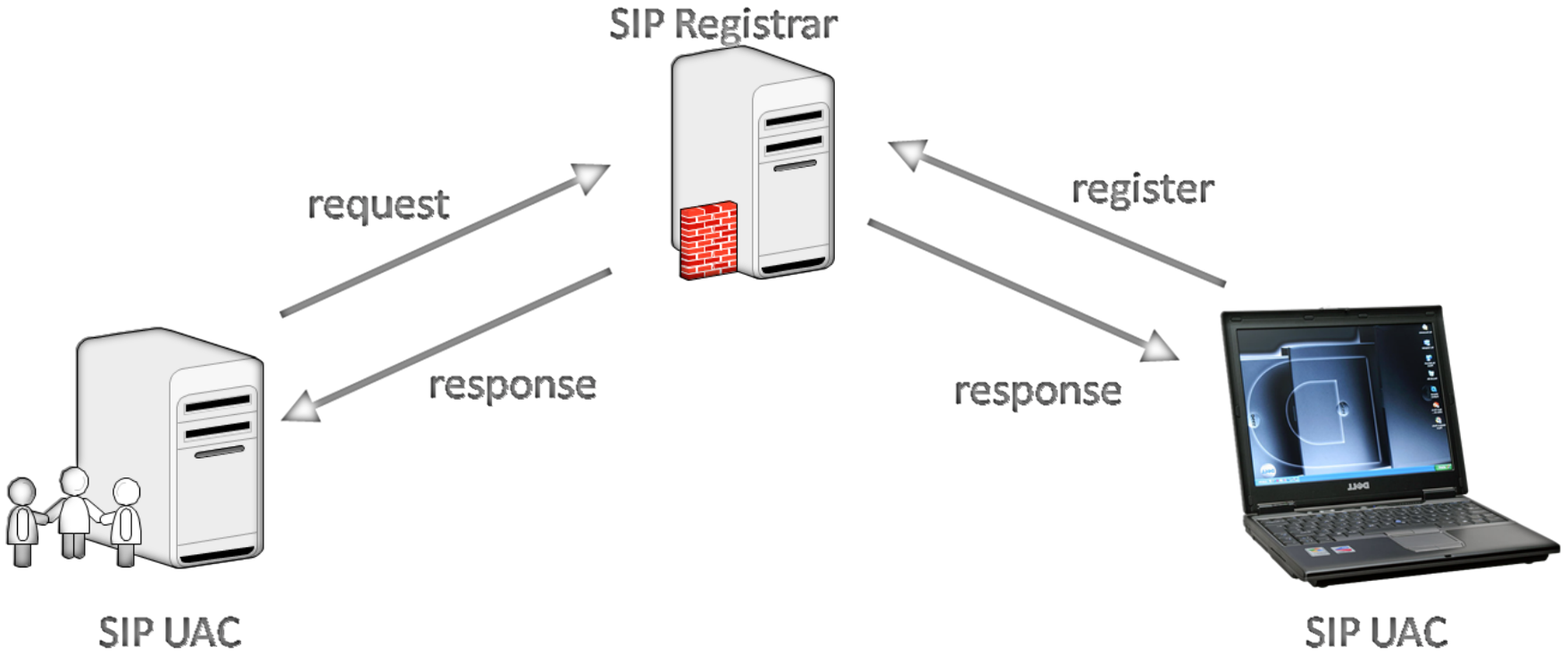
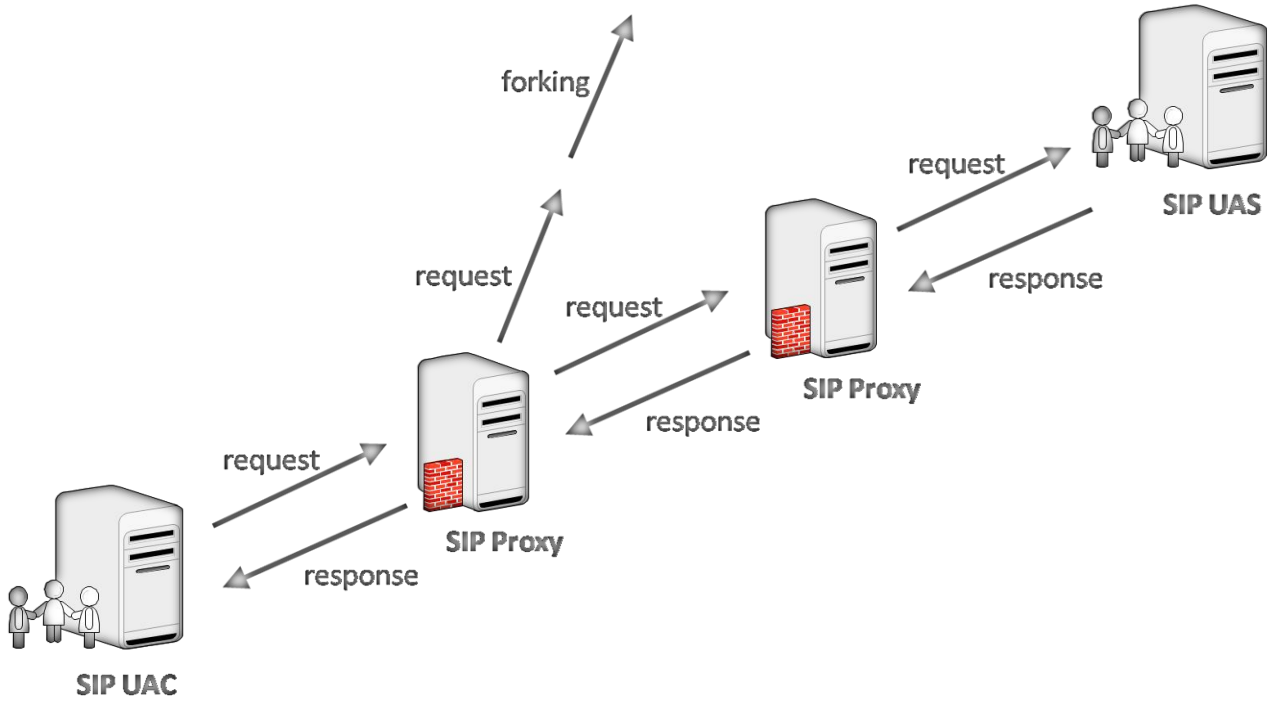
Registrar



- Registrar receives Registration from clients (UA) regarding current location and stores in a location server (non-SIP)
- This information is used for routing (terminating) the call

Proxy Server



- Forwards client requests to another proxy or UA
- Either maintain call state (stateful) or can be stateless
- Can fork request to multiple servers (parallel search)
- Softswitch / Gatekeeper function

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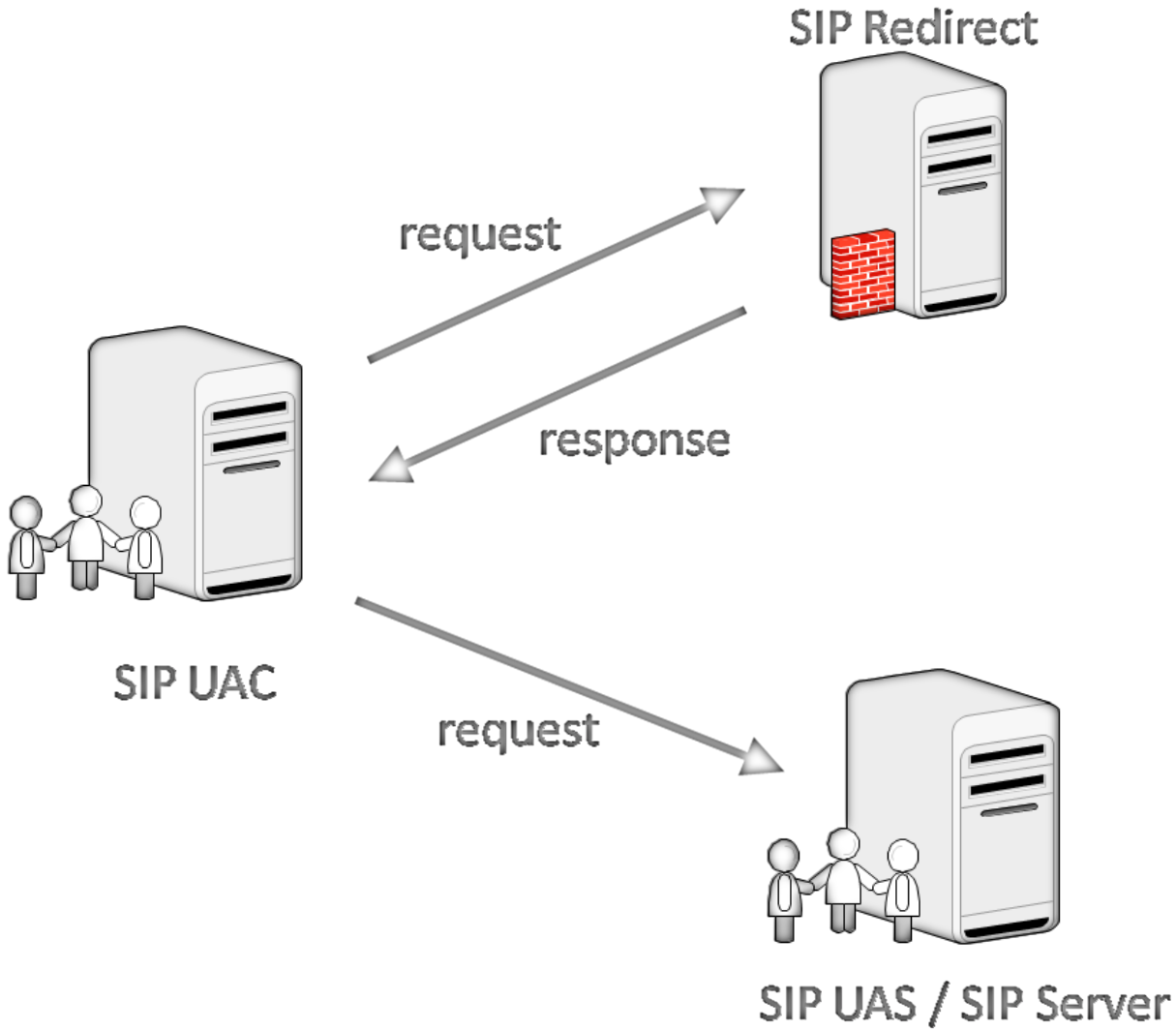
Redirect Server

- Returns the next address to originator instead of forwarding
- Originator retries with the new address



SIP Messages

Request and Response messages

Request Messages:

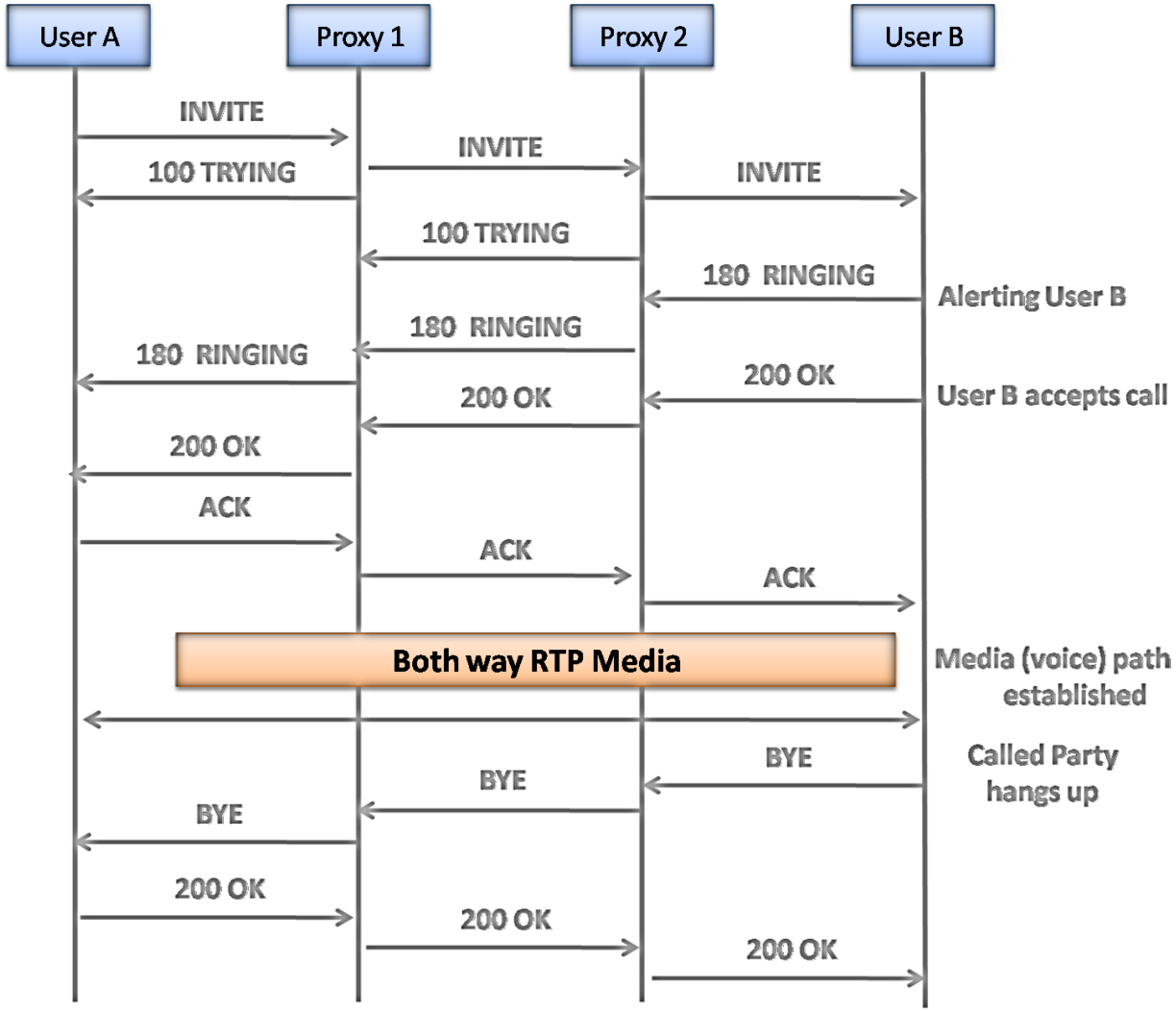
- REGISTER – For registration
- INVITE – Session initiation
- ACK – Acknowledge Invite Response
- BYE – Successful session termination
- CANCEL- Terminate the pending request

Response Messages:

- 1xx: Information (100 trying, 180 ringing)
- 2xx: Successful (200 OK)
- 3xx: Redirection (301 Moved permanently)
- 4xx: Client error (400 Bad Request, 404 Not found)
- 5xx: Server error (503 Service unavailable)
- 6xx: Global error (600 Busy Everywhere, 603 Decline)

Call Flow

Session Initiation Protocol



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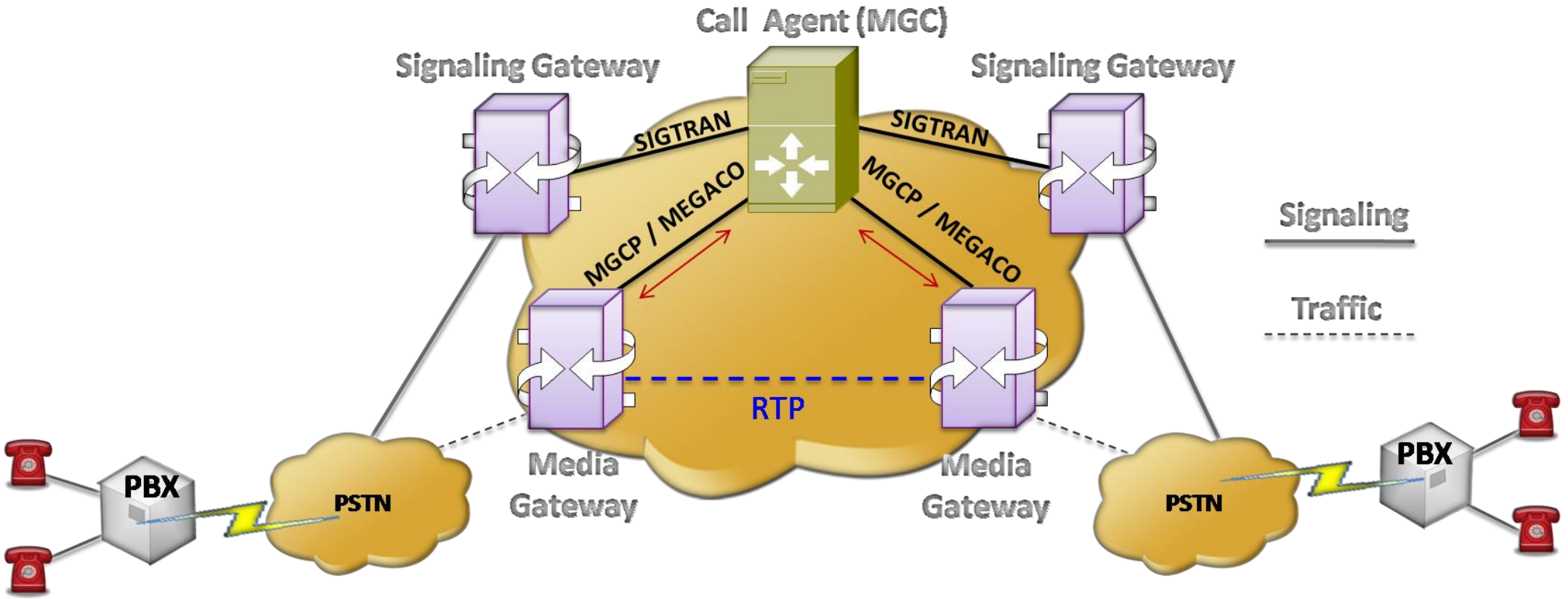
Media Gateway Control Protocol



Media Gateways (MG)

- An interface between PSTN and IP network
- Converts and passes Speech samples between the two networks
  - PCM on PSTN ⬅===➔ RTP (different codecs) on IP
- Communicates with MGC for call handling using MEGACO / MGCP
- Responsible for feeding tones / digit collection / off hook / on hook detection, voice compression etc.
- Highly hardware intensive (DSP, embedded systems)

Signaling Gateways (SG)

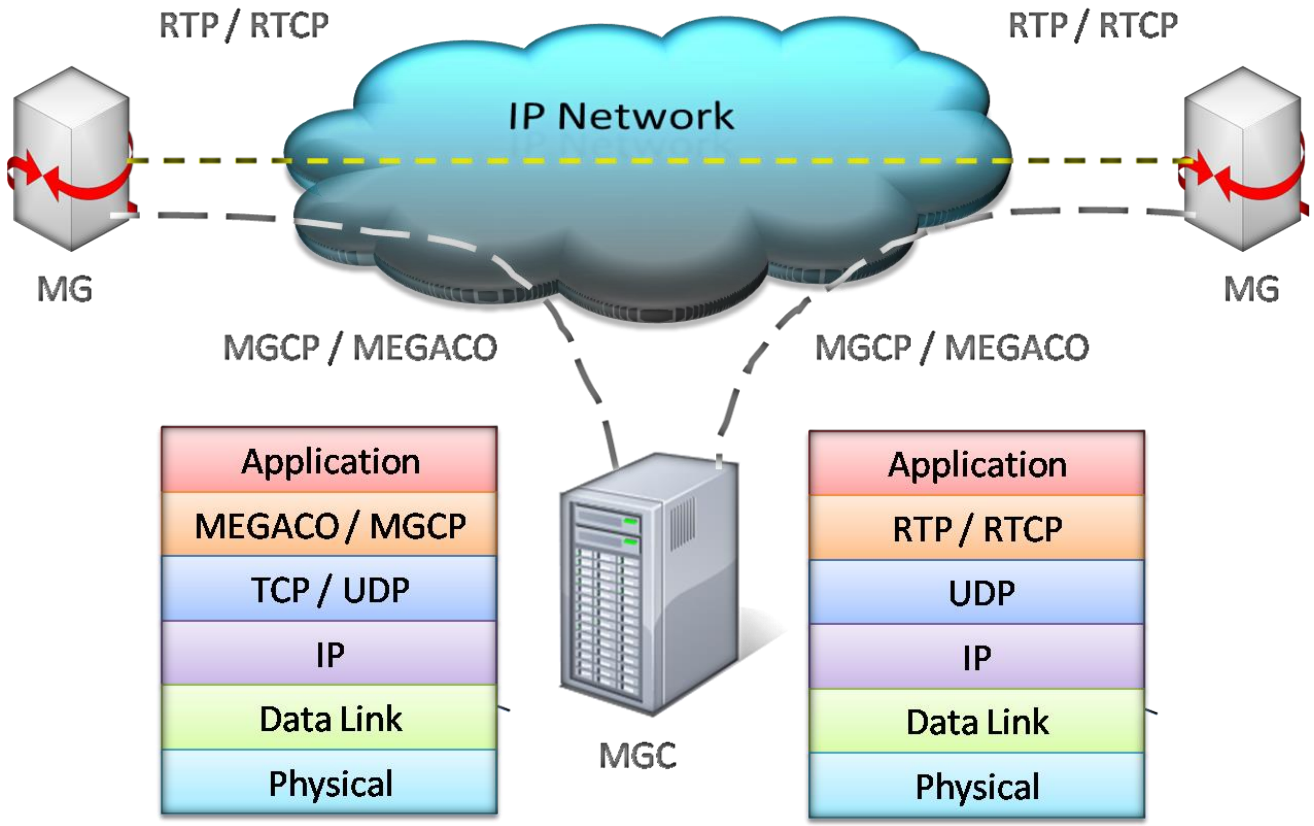
- Signaling Gateway is a network component
- Responsible for transferring signaling messages (i. e. information related to call establishment, billing, location, short messages, address conversion, and other services) between Common Channel Signaling (CCS) nodes that communicate using different protocols and transports
- Transport conversion is often from SS7 to IP

Example: A SIGTRAN Signaling Gateway is a network component that performs packet level translation of signaling from common channel signaling (based upon SS7) to SIGTRAN signaling (based upon IP)

Media Gateway Controller (MGC)

- Also called as Call agent
- Entity responsible for monitoring and controlling media endpoints, media resources and media connections
- Controls MGs using MEGACO/MGCP
- Highly software intensive and mostly uses standard computing hardware platform like sun servers

Gateway Control Protocols

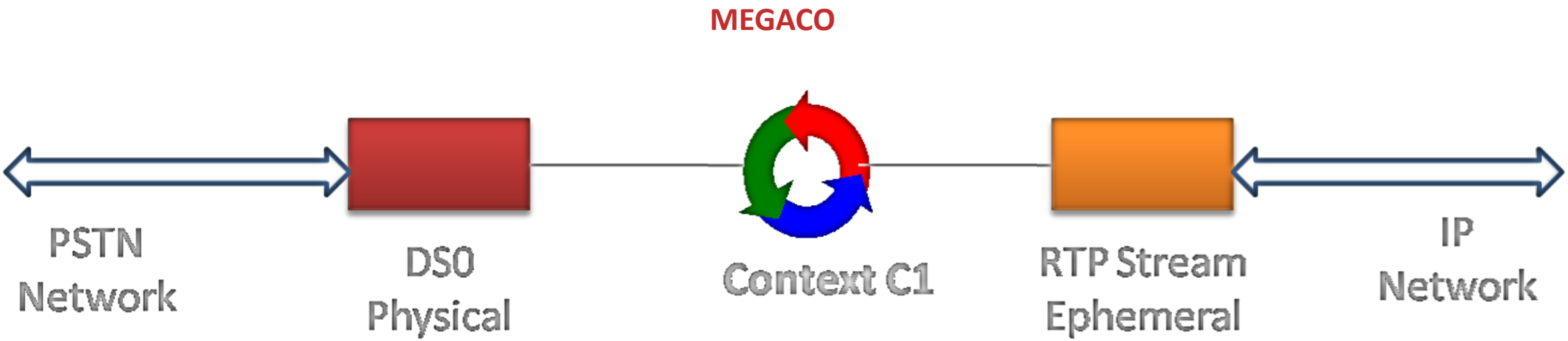


MEGACO

MEGACO

- Megaco (or H.248) is an implementation of the Media Gateway Control Protocol architecture for controlling Media Gateways on Internet Protocol (IP) networks and the public switched telephone network (PSTN)
- Megaco defines the protocol for Media Gateway Controllers to control Media Gateways for the support of multimedia streams across computer networks
- It is typically used to provide Voice over Internet Protocol (VoIP) services (voice and fax) between IP networks and the PSTN, or entirely within IP networks

MEGACO Connection Model



Termination

- A Termination sources and/or sinks one or more streams
- Two kinds of Terminations
  - ➢Physical Termination - Ex: DS0
  - ➢Ephemeral Termination - Ex: RTP Stream, exists only for the duration of there usage
- Terminations are characterized by different descriptors such as Signals (dial tone), Events (on/off hook), Digit Map and Media descriptors. These descriptors can be applied to terminations by MGC
- Terminations have unique identities (TerminationIDs), assigned by the MG at the time of their creation
- Root Termination refers to all terminations in the MG
- Wild Cards :
  - ➢* -> Refers to all terminations in a context.
  - ➢$ -> MGC asks MG to choose TerminationID for a termination

Context

- Context is an association between a collection of Terminations
- Created by MG when the first Termination is added to it
- Contexts are deleted implicitly when the last remaining Termination is subtracted or moved out
- Contains unique identifiers (ContextIDs), assigned by the MG at the time of creation
- A Termination exists in only one Context at a time
- Null Context is a special type of Context, which contains all Terminations that are not associated to any other Termination. For instance, in a decomposed access gateway, all idle lines are represented by Terminations in the null Context
- Wild Cards:
  - * -> Refers to all Contexts in the MG
  - - -> Refers to NULL Context
  - $ -> MGC refers MG to choose one ContextID

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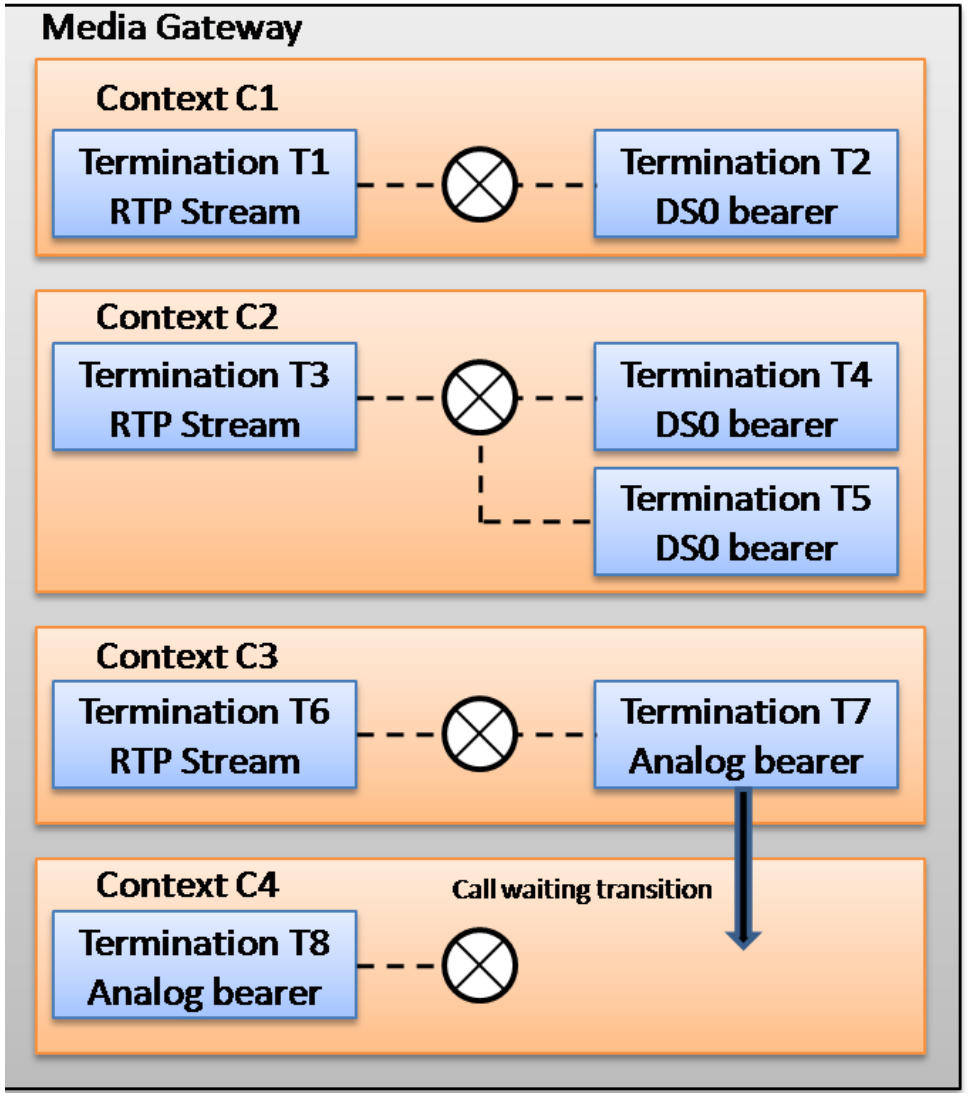
MEGACO Termination and Context



Packages

- Packages are groups of Properties, Signals, Events, and Statistics for the termination
- Each Termination is associated with packages. Ex: Analog Line Supervision Package, Tone Detection Package, DTMF Generator Package
- Properties, Events, Signals and Statistics defined in Packages, as well as parameters to them, are referenced by identifiers (Ids). Ex: For Analog Line Supervision Package is refered as “al”

Signals

- MGC orders MG to apply a signal
- Signals are applied to terminations
  - e.g. Dial tone, Ring, DTMF tones (O/G side)
- Can apply Set of signals in a sequence
- Signal Type
  - on/off (e.g. Announcements)
  - Timeout (e.g. dial tone, ring)
  - Brief (e.g. DTMF tone)

Events

- **MGC orders MG to detect events**
- **Events are detect by MG on termination**
  - e.g. on/off hook, DTMF digits
- **MG notifies the requested events after detection**
- **List of events can be requested**
- **Embedding with another Event/Signal**
  - e.g detect Off hook event and apply dial tone signal

Digit Map

- Simple way to instruct MG to collect sequence of digits as per dial plan
- (0S|00S|[1-7]xLxx|8Lxxxxxxx|*xx|9L1xxx)
  - S short timer
  - L Long timer
  - x any digit
  - | or
  - [1-7] Any digit between 1 to 7
- MG will look for the best match and report the digits to MGC

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Media Descriptor

- Specifies the parameters for all the media streams
- Media descriptor types
  - TerminationState Descriptor
  - Stream descriptor
    - LocalControl descriptor
    - Local descriptor
    - Remote descriptor

Terminator State Descriptor

- Specifies the service state of the termination
- A Termination can be in one of the following states: "test", "out of service", or "in service"
- The EventBufferControl property specifies whether events are buffered following detection of an event in the Events descriptor, or processed immediately

Local Control, Local and Remote Descriptor

Local Control Descriptor

- Specifies the mode property of a stream such as send-only, receive-only, send/receive, inactive and loop-back
- ReserveGroup and ReserveValue indicate the resources should be reserved for all alternatives specified in the Local and/or Remote descriptors for which it currently has resources available

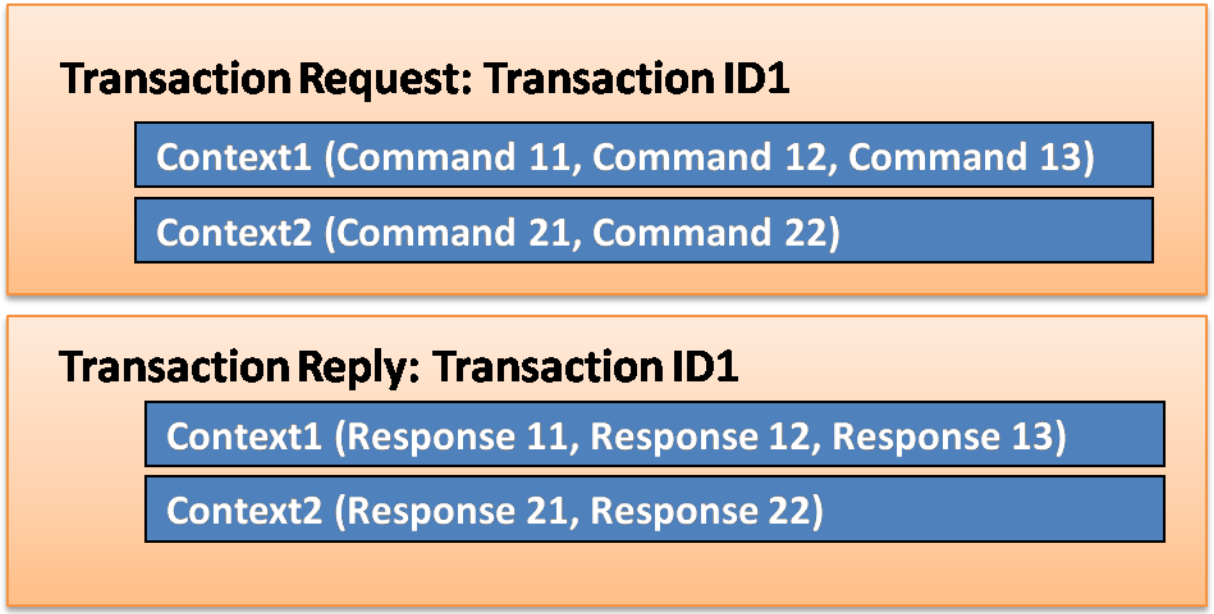
Local and Remote Descriptor

- The MGC uses Local and Remote descriptors to reserve and commit MG resources for media decoding and encoding for the given Stream(s) and Termination to which they apply
- Session Description Protocol is used for describe media session
- Local refers to the media received by the MG and Remote refers to the media sent by the MG

Service Charge Descriptor

- Used only in association with ServiceChange command
- Type of service change
  - ServiceChangeMethod
    - Graceful, the removal of existing terminations w/o interrupting existing connections.
    - Forced, an abrupt removal
    - Restart, after a specified delay
    - Disconnected, applied to the entire MG
    - Handoff, from the old MGC; a new MGC is taking over
    - Failover, from MG to MGC
  - ServiceChangeDelay, a number of seconds
  - SericeChangeReason, reason why the ServiceChange has or will occur
  - ServiceChangesAddress, address (e.g., IP port number for IP networks) to be used for subsequent communications

MEGACO Transactions



- TransactionRequest: Consists of one or more commands. Each transaction will have an TransactionID
- TransactionReply: Consists of one or more replies for the requests
- TransactionResponseAck: Acknowledges received TransctionReply
- TransactionPending: Indicates the receipt of request and is under process

MEGACO Commands

Add (MGC to MG)

- Adds a termination to a context
- Add on first termination creates the context

Modify (MGC to MG)

- Modifies the properties, events and signals of a termination
- E.g., to issue signals (dial tone) or to detect specific events (on/off hook)

Move (MGC to MG)

- Moves a termination to another context
- Can not be moved to null context

MEGACO Commands

Substract (MGC to MG)

- Disconnects a termination from a context
- Returns statistics of that termination
- If last termination, deletes the context

Notify (MG to MGC)

- Informs MGC about the occurrence of requested events

Audit Value (MGC to MG)

- Retrieves current values of properties, events and signals of a termination

Audit Capability (MGC to MG)

- Retrieves all the possible values for properties, events and signals of a termination

MEGACO Commands

Service Change (mainly from MGC to MG)

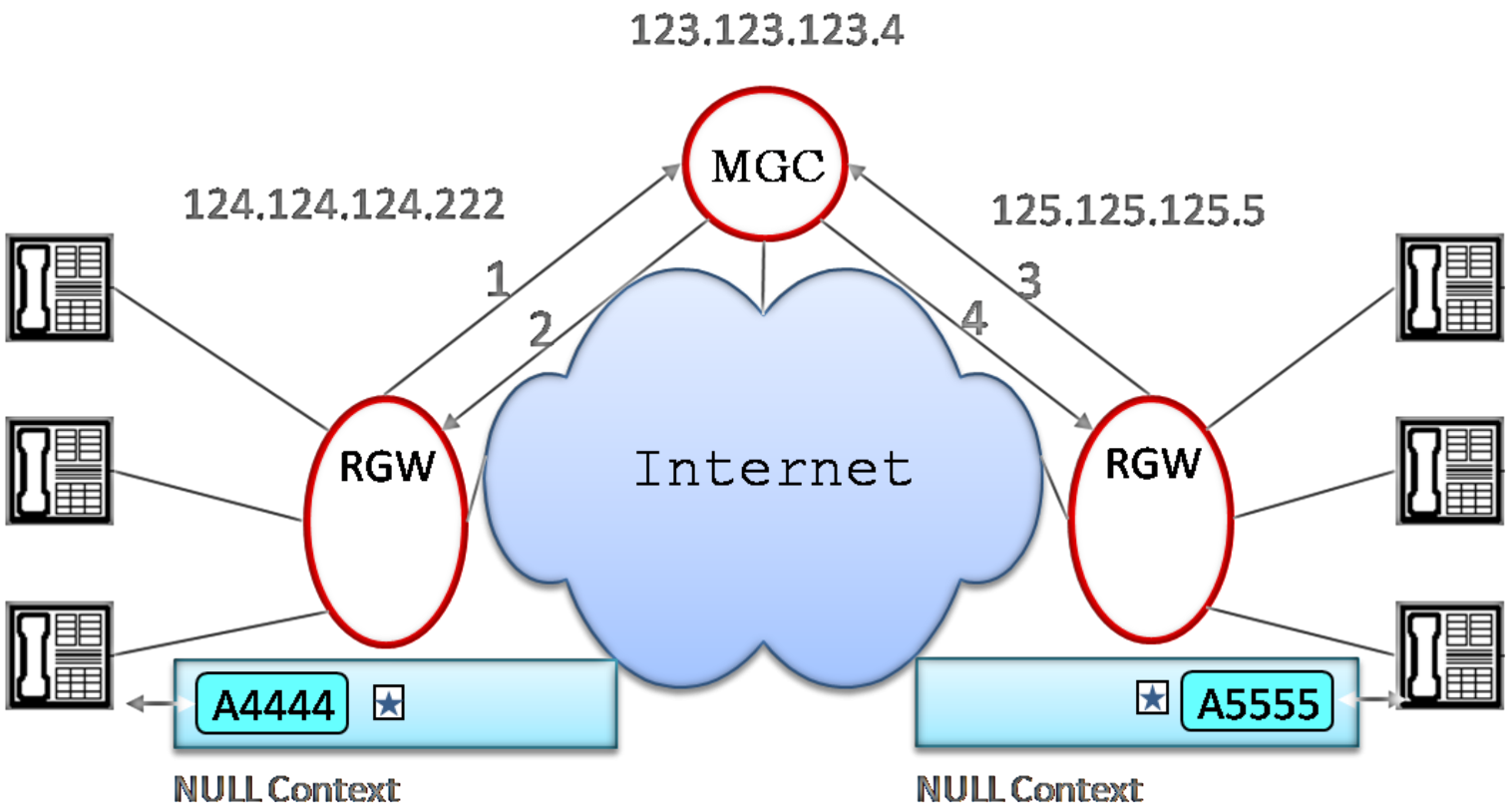
- Needed for MG registration with MGC
- Indicates termination state (out of service/ in service) by MG
- Handover to another MGC by MGC
- Request MG to take termination out of service

MEGACO Message Example

```
MEGACO/1  [130.202.9.126]:33333
Transaction = 10003  {
                Context = -  {
                        Modify = ds31/ds13/ds05   {
                                Events  = 2223  {
                                        al/on, dd/ce {DigitMap=DialPlan0}
                                Signals  {cg/dt},
                                DigitMap = DialPlan0 {
                                                (os|00s||8Lxxxx)}
                        }
                }
}
---------------------------------------------------------------------
MEGACO/1 [130.202.9.121]:55555
Reply = 10003  {
                Context = -  {Modify = ds31/ds13/ds05 }
```

Call Flow – RGW to RGW

MEGACO



1.(3) ServiceChange(ROOT): MG register with MGC

2.(4) Modify(A4444): MGC set Mode(SendReceive) & Events(al/of)

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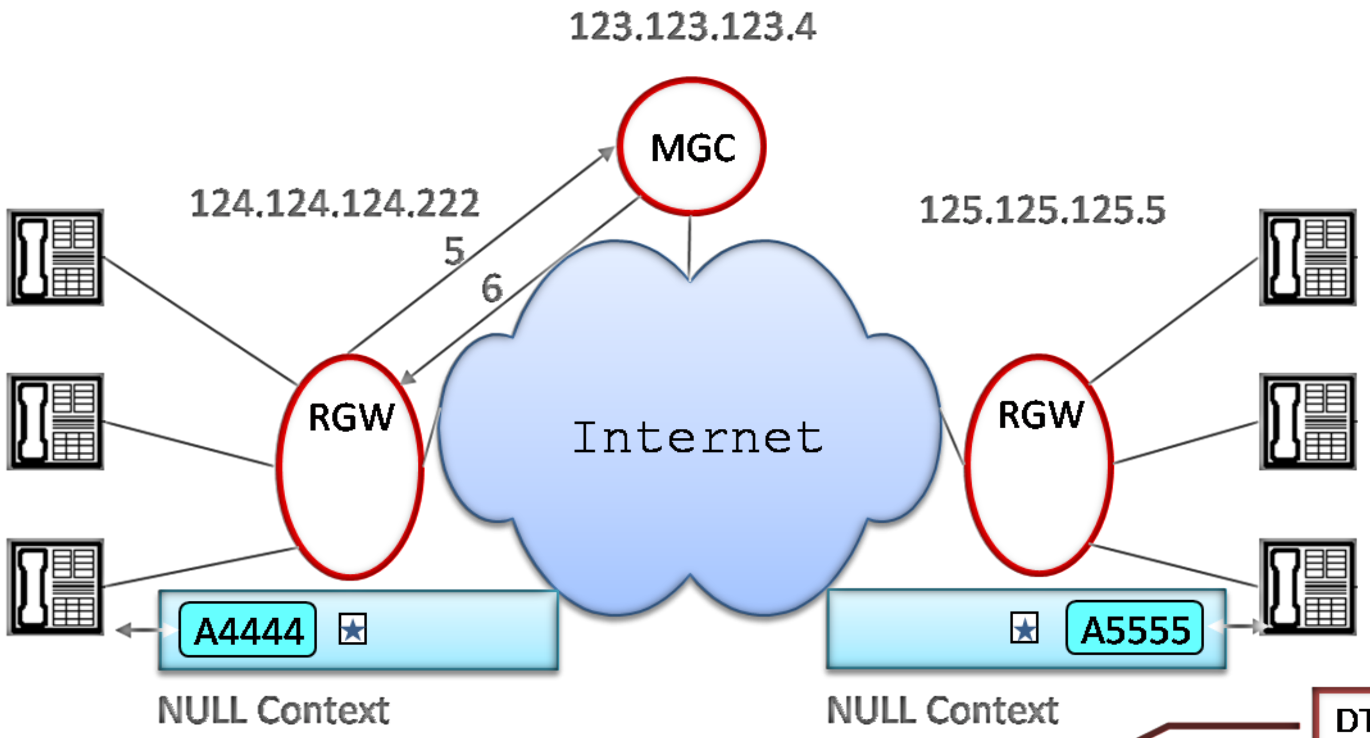
Call Flow – RGW to RGW

MEGACO



5. Notify(A4444): MG report an off hook event(time)
6. Modify(A4444): MGC set Events(al/on, dd/ce, {DigitMap = Dialplan0})
   Signals(cg/dt)
   DigitMap = Dialplan0{…}

DTMF detection/
Digit Map Complete Event

Call Progress Tone Generator/Dial Tone

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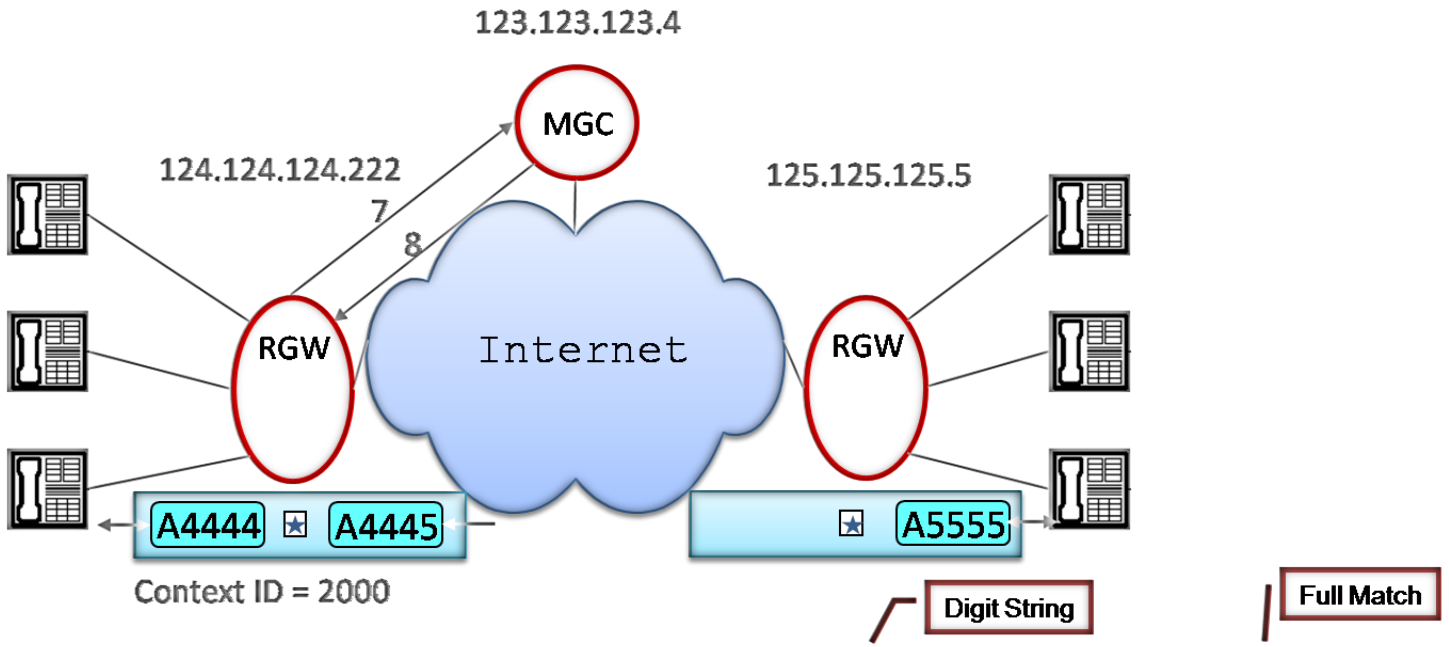
Call Flow – RGW to RGW

MEGACO



7. Notify(A4444): MG report a Digit Map Complete event(ds=916135551212,Meth=FM)

8. Add(A4444,$:Mode(ReceiveOnly), Local(RTP))

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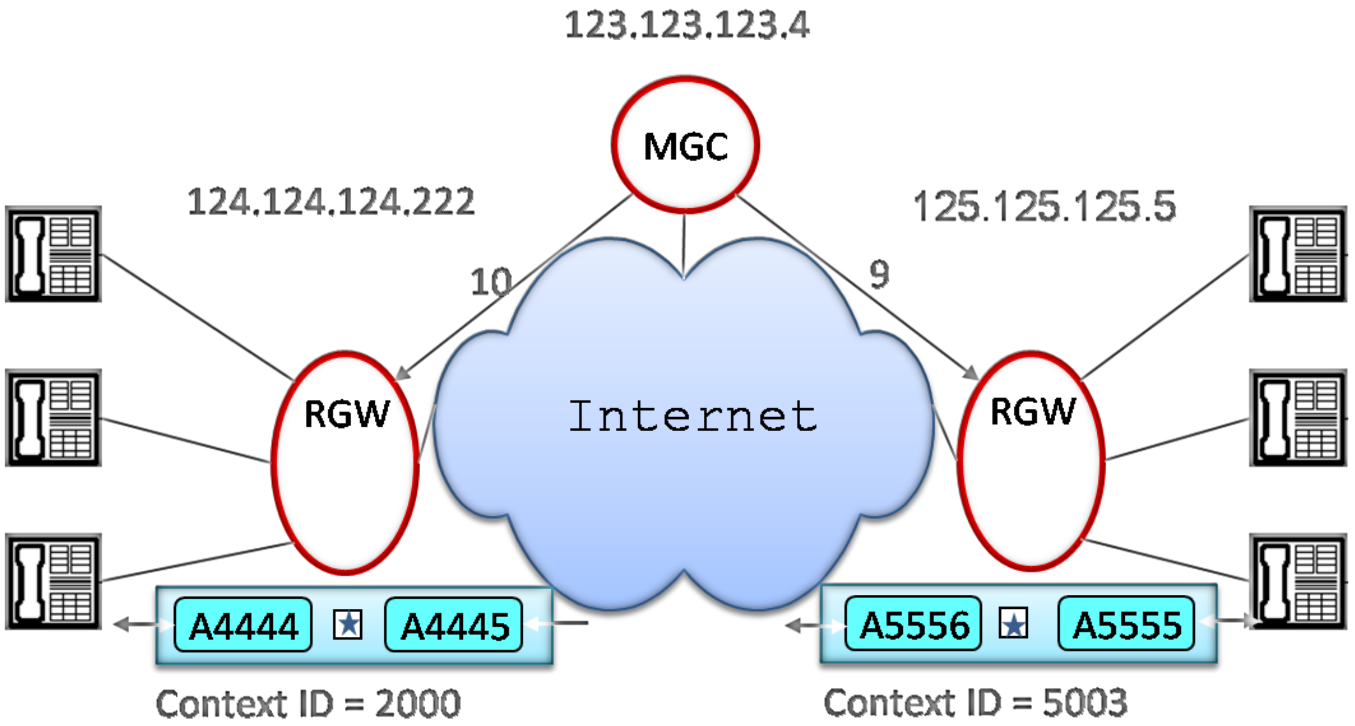
Call Flow – RGW to RGW

MEGACO



9. Add(A5555: Mode(SendReceive), Events(al/of), Signals(al/ri),
$: Mode(SendReceive), Local(RTP), Remote(…))
10. Modify(A4444: Signals(cg/rt)); Modify(A4445: Remote(…))

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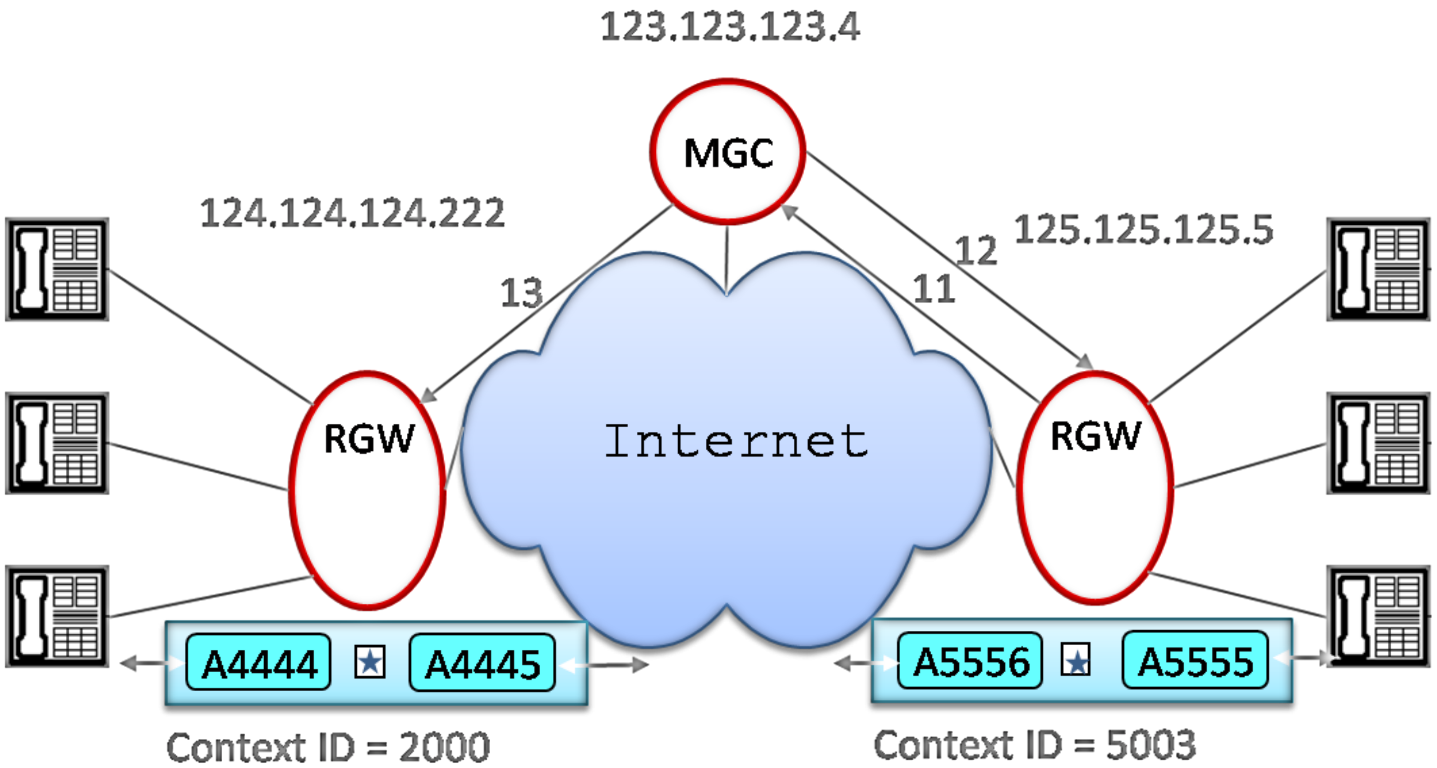
Call Flow – RGW to RGW

MEGACO



11. Notify(A5555: Observed(al/of))
12. Modify(A5555: Events(al/on), Signals()); to turn off ringing
13. Modify(A4445: Mode(SendReceive)); Modify(A4444: Signals())

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THANK YOU!